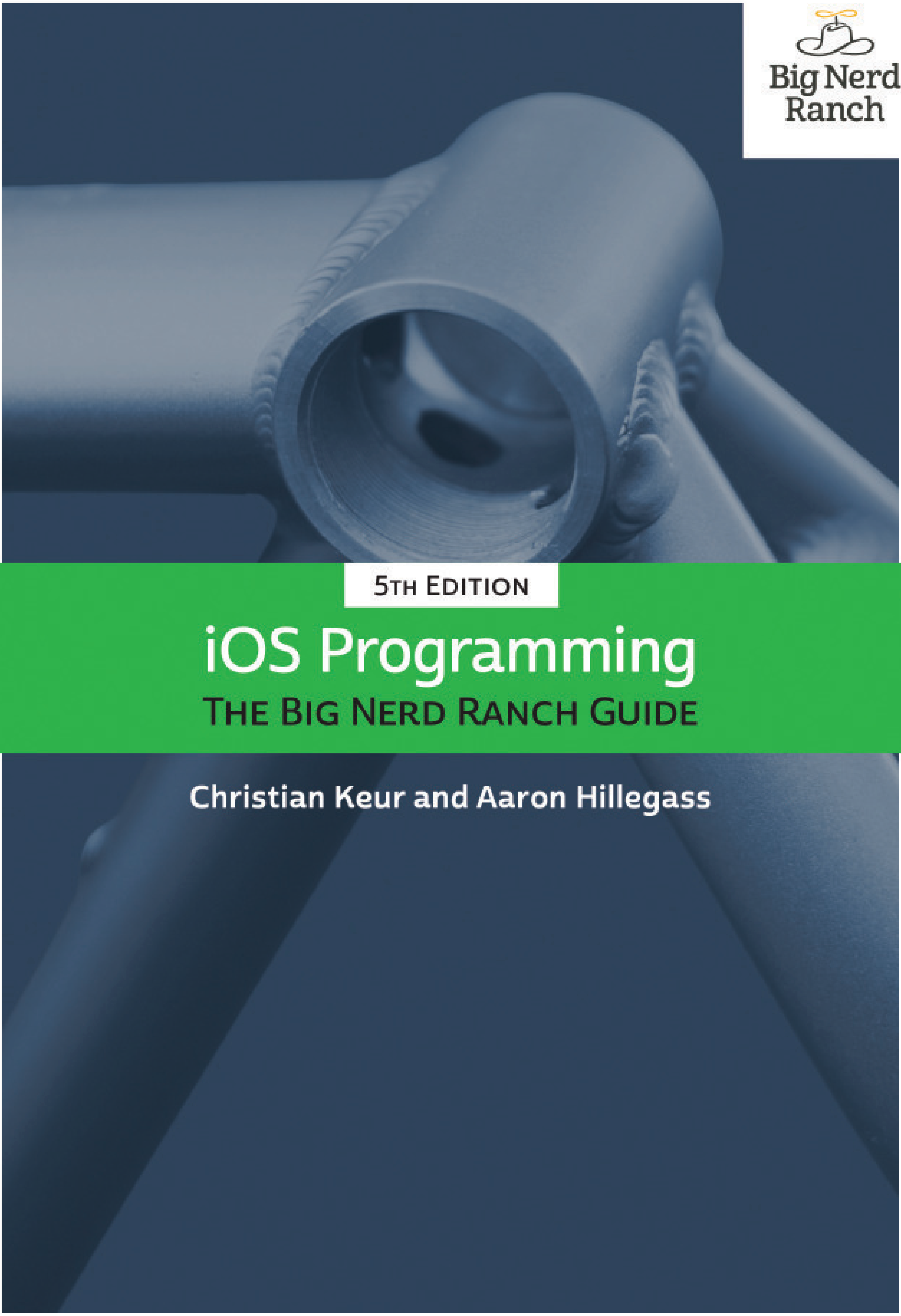

Big Nerd Ranch

5th Edition

iOS Programming

The Big Nerd Ranch Guide

Christian Keur and Aaron Hillegass

iOS Programming: The Big Nerd Ranch Guide

by Christian Keur and Aaron Hillegass

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Introduction

As an aspiring iOS developer, you face three major tasks:

- *You must learn the Swift language.* Swift is the recommended development language for iOS. The first two chapters of this book are designed to give you a working knowledge of Swift.
- *You must master the big ideas.* These include things like delegation, archiving, and the proper use of view controllers. The big ideas take a few days to understand. When you reach the halfway point of this book, you will understand these big ideas.
- *You must master the frameworks.* The eventual goal is to know how to use every method of every class in every framework in iOS. This is a project for a lifetime: there are hundreds of classes and thousands of methods available in iOS, and Apple adds more classes and methods with every release of iOS. In this book, you will be introduced to each of the subsystems that make up the iOS SDK, but you will not study each one deeply. Instead, our goal is to get you to the point where you can search and understand Apple’s reference documentation.

We have used this material many times at our iOS bootcamps at Big Nerd Ranch. It is well tested and has helped thousands of people become iOS developers. We sincerely hope that it proves useful to you.

Prerequisites

This book assumes that you are already motivated to learn to write iOS apps. We will not spend any time convincing you that the iPhone, iPad, and iPod touch are compelling pieces of technology.

We also assume that you have some experience programming and know something about object-oriented programming. If this is not true, you should probably start with *Swift Programming: The Big Nerd Ranch Guide*.

What Has Changed in the Fifth Edition?

All of the code in this book is Swift, and an early chapter is devoted to getting you up to speed with this new language. Throughout the book, you will see how to use Swift’s capabilities and features to write better iOS applications. We have come to love Swift at Big Nerd Ranch and believe you will, too.

Other additions include collection views and size classes and improved coverage of Auto Layout, web services, and Core Data.

This edition assumes that the reader is using Xcode 7.1 or later and running applications on an iOS 9 or later device.

Besides these obvious changes, we made thousands of tiny improvements that were inspired by questions from our readers and our students. Every chapter of this book is just a little better than the corresponding chapter from the fourth edition.

Our Teaching Philosophy

This book will teach you the essential concepts of iOS programming. At the same time, you will type in a lot of code and build a bunch of applications. By the end of the book, you will have knowledge *and* experience. However, all the knowledge should not (and, in this book, will not) come first. That is the traditional way we have all come to know and hate. Instead, we take a learn-while-doing approach. Development concepts and actual coding go together.

Here is what we have learned over the years of teaching iOS programming:

- We have learned what ideas people must grasp to get started programming, and we focus on that subset.
- We have learned that people learn best when these concepts are introduced *as they are needed*.
- We have learned that programming knowledge and experience grow best when they grow together.
- We have learned that "going through the motions" is much more important than it sounds. Many times we will ask you to start typing in code before you understand it. We realize that you may feel like a trained monkey typing in a bunch of code that you do not fully grasp. But the best way to learn coding is to find and fix your typos. Far from being a drag, this basic debugging is where you really learn the ins and outs of the code. That is why we encourage you to type in the code yourself. You could just download it, but copying and pasting is not programming. We want better for you and your skills.

What does this mean for you, the reader? To learn this way takes some trust – and we appreciate yours. It also takes patience. As we lead you through these chapters, we will try to keep you comfortable and tell you what is happening. However, there will be times when you will have to take our word for it. (If you think this will bug you, keep reading – we have some ideas that might help.) Do not get discouraged if you run across a concept that you do not understand right away. Remember that we are intentionally *not* providing all the knowledge you will ever need all at once. If a concept seems unclear, we will likely discuss it in more detail later when it becomes necessary. And some things that are not clear at the beginning will suddenly make sense when you implement them the first (or the twelfth) time.

People learn differently. It is possible that you will love how we hand out concepts on an as-needed basis. It is also possible that you will find it frustrating. In case of the latter, here are some options:

- Take a deep breath and wait it out. We will get there, and so will you.
- Check the index. We will let it slide if you look ahead and read through a more advanced discussion that occurs later in the book.
- Check the online Apple documentation. This is an essential developer tool, and you will want plenty of practice using it. Consult it early and often.
- If Swift or object-oriented programming concepts are giving you a hard time (or if you think they will), you might consider backing up and reading our *Swift Programming: The Big Nerd Ranch Guide*.

How to Use This Book

This book is based on the class we teach at Big Nerd Ranch. As such, it was designed to be consumed in a certain manner.

Set yourself a reasonable goal, like “I will do one chapter every day.” When you sit down to attack a chapter, find a quiet place where you will not be interrupted for at least an hour. Shut down your email, your Twitter client, and your chat program. This is not a time for multitasking; you will need to concentrate.

Do the actual programming. You can read through a chapter first, if you like. But the real learning comes when you sit down and code as you go. You will not really understand the idea until you have written a program that uses it and, perhaps more importantly, debugged that program.

A couple of the exercises require supporting files. For example, in the first chapter you will need an icon for your Quiz application, and we have one for you. You can download the resources and solutions to the exercises from .

There are two types of learning. When you learn about the Peloponnesian War, you are simply adding details to a scaffolding of ideas that you already understand. This is what we will call “Easy Learning.” Yes, learning about the Peloponnesian War can take a long time, but you are seldom flummoxed by it. Learning iOS programming, on the other hand, is “Hard Learning,” and you may find yourself quite baffled at times, especially in the first few days. In writing this book, we have tried to create an experience that will ease you over the bumps in the learning curve. Here are two things you can do to make the journey easier:

- Find someone who already knows how to write iOS applications and will answer your questions. In particular, getting your application onto a device the first time is usually very frustrating if you are doing it without the help of an experienced developer.

- Get enough sleep. Sleepy people do not remember what they have learned.

How This Book Is Organized

In this book, each chapter addresses one or more ideas of iOS development through discussion and hands-on practice. For more coding practice, most chapters include challenge exercises. We encourage you to take on at least some of these. They are excellent for firming up your grasp of the concepts introduced in the chapter and for making you a more confident iOS programmer. Finally, most chapters conclude with one or two “For the More Curious” sections that explain certain consequences of the concepts that were introduced earlier.

Chapter 1 introduces you to iOS programming as you build and deploy a tiny application. You will get your feet wet with Xcode and the iOS simulator along with all the steps for creating projects and files. The chapter includes a discussion of Model-View-Controller and how it relates to iOS development.

Chapter 2 provides an overview of Swift, including basic syntax, types, optionals, initialization, and how Swift is able to interact with the existing iOS frameworks. You will also get experience working in a playground, Xcode’s new code prototyping tool.

In Chapter 3, you will focus on the iOS user interface as you learn about views and the view hierarchy and create an application called WorldTrotter.

Chapter 4 introduces delegation, an important iOS design pattern. You will also a text field to WorldTrotter.

In Chapter 5, you will expand WorldTrotter and learn about using view controllers for managing user interfaces. You will get practice working with views and view controllers as well as navigating between screens using a tab bar.

In Chapter 6, you will learn how to manage views and view controllers in code. You will add a segmented control to WorldTrotter that will let you switch between various map types.

Chapter 7 introduces the concepts and techniques of internationalization and localization. You will learn about **NSLocale**, strings tables, and **NSBundle** as you localize parts of WorldTrotter.

In Chapter 8, you will learn about and add different types of animations to the Quiz project that you created in Chapter 1.

Chapter 9 introduces the largest application in the book – Homepwner. (By the way, “Homepwner” is not a typo; you can find the definition of “pwn” at www.urbandictionary.com.) This application keeps a record of your items in case of fire or other catastrophe. Homepwner will take eight chapters to complete.

In Chapter 9 - Chapter 11, you will work with tables. You will learn about table views, their view controllers, and their data sources. You will learn how to display data in a table, how to allow the user to edit the table, and how to improve the interface.

Chapter 12 introduces stack views that will help you create complex interfaces very easily. You will use a stack view to add a new screen to Homepwner that displays the details for a single item.

Chapter 13 builds on the navigation experience gained in Chapter 5. You will use **UINavigationController** to give Homepwner a drill-down interface and a navigation bar.

Chapter 14 introduces the camera. You will take pictures and display and store images in Homepwner.

In Chapter 15, you will add persistence to Homepwner using archiving to save and load the application data.

In Chapter 16, you will learn about size classes, and you will use these to update Homepwner’s interface to scale well across various screen sizes.

In Chapter 17 and Chapter 18, you will create a drawing application named TouchTracker to learn about touch events. You will see how to add multitouch capability and how to use **UIGestureRecognizer** to respond to particular gestures. You will also get experience with the first responder and responder chain concepts and more practice with using structures and dictionaries.

Chapter 19 introduces web services as you create the Photorama application. This application fetches and parses JSON from a server using **NSURLSessions** and **NSJSONSerialization**.

In Chapter 20, you will learn about collection views as you build an interface for Photorama using **UICollectionView** and **UICollectionViewCell**.

In Chapter 21 and Chapter 22, you will add persistence to Photorama using Core Data. You will store and load images and associated data using an **NSManagedObjectContext**.

Style Choices

This book contains a lot of code. We have attempted to make that code and the designs behind it exemplary. We have done our best to follow the idioms of the community, but at times we have wandered from what you might see in Apple's sample code or code you might find in other books. In particular, you should know up-front that we nearly always start a project with the simplest template project: the single view application. When your app works, you will know it is because of your efforts – not because that behavior was built into the template.

Typographical Conventions

To make this book easier to read, certain items appear in certain fonts. Classes, types, methods, and functions appear in a bold, fixed-width font. Classes and types start with capital letters, and methods and functions start with lowercase letters. For example, "In the **loadView()** method of the **RexViewController** class, create a constant of type **String**."

Variables, constants, and filenames appear in a fixed-width font but are not bold. So you will see, "In ViewController.swift, add a variable named fido and initialize it to "Rufus"."

Application names, menu choices, and button names appear in a sans serif font. For example, "Open Xcode and select New Project... from the File menu. Select Single View Application and then click Choose...."

All code blocks are in a fixed-width font. Code that you need to type in is always bold. For example, in the following code, you would type in the two lines beginning **@IBOutlet**. The other lines are already in the code and are included to let you know where to add the new lines.

```
import UIKit

class ViewController: UIViewController {

    @IBOutlet var questionLabel: UILabel!
    @IBOutlet var answerLabel: UILabel!

}
```

Necessary Hardware and Software

To build the applications in this book, you must have a Mac running OS X Yosemite (10.10.5) or later. You will also need Xcode, Apple's Integrated Development Environment, which is available on the App Store. Xcode includes the iOS SDK, the iOS simulator, and other development tools.

You should join the Apple Developer Program, which costs $99/year, because:

- Downloading the latest developer tools is free for members.

- You cannot put an app in the store until you are a member.

If you are going to take the time to work through this entire book, membership in the Apple Developer Program is worth the cost. Go to http://developer.apple.com/programs/ios/ to join.

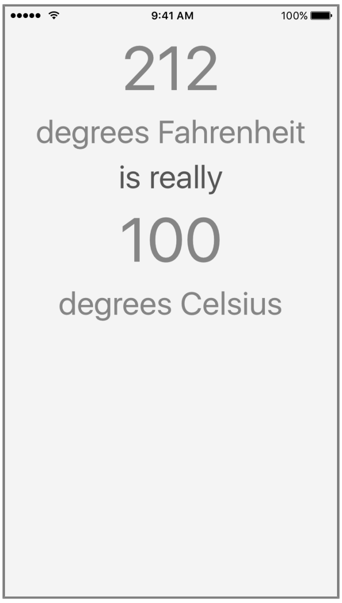
What about iOS devices? Most of the applications you will develop in the first half of the book are for iPhone, but you will be able to run them on an iPad. On the iPad screen, iPhone applications appear in an iPhone-sized window. Not a compelling use of iPad, but that is OK when you are starting with iOS. In the early chapters, you will be focused on learning the fundamentals of the iOS SDK, and these are the same across iOS devices. Later in the book, you will see how to make applications run natively on both iOS device families.

Excited yet? Good. Let’s get started.

3 Views and the View Hierarchy

Over the next five chapters, you are going to build an application named WorldTrotter. When it is complete, this app will convert values between degrees Fahrenheit and degrees Celsius. In this chapter, you will learn about views and the view hierarchy through creating WorldTrotter's user interface. At the end of this chapter, your app will look like Figure 3.1.

Figure 3.1 WorldTrotter



Let's start with a little bit of the theory behind views and the view hierarchy.

View Basics

Recall from Chapter 1 that views are objects that are visible to the user, like buttons, text fields, and sliders. View objects make up an application's user interface. A view

- is an instance of **`UIView`** or one of its subclasses
- knows how to draw itself
- can handle events, like touches
- exists within a hierarchy of views whose root is the application's window

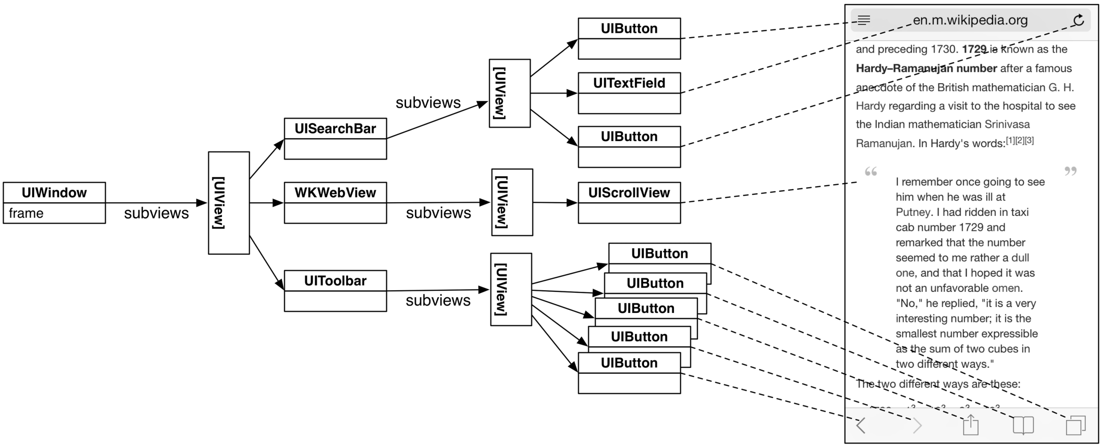
Let's look at the *view hierarchy* in greater detail.

The View Hierarchy

Every application has a single instance of **`UIWindow`** that serves as the container for all the views in the application. **`UIWindow`** is a subclass of **`UIView`**, so the window is itself a view. The window is created when the application launches. Once the window is created, other views can be added to it.

When a view is added to the window, it is said to be a *subview* of the window. Views that are subviews of the window can also have subviews, and the result is a hierarchy of view objects with the window at its root (Figure 3.2).

Figure 3.2 An example view hierarchy and the interface that it creates



and preceding 1730. **1729** is known as the **Hardy–Ramanujan number** after a famous anecdote of the British mathematician G. H. Hardy regarding a visit to the hospital to see the Indian mathematician Srinivasa Ramanujan. In Hardy's words:[1][2][3]

> I remember once going to see him when he was ill at Putney. I had ridden in taxi cab number 1729 and remarked that the number seemed to me rather a dull one, and that I hoped it was not an unfavorable omen. "No," he replied, "it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways."

The two different ways are these:

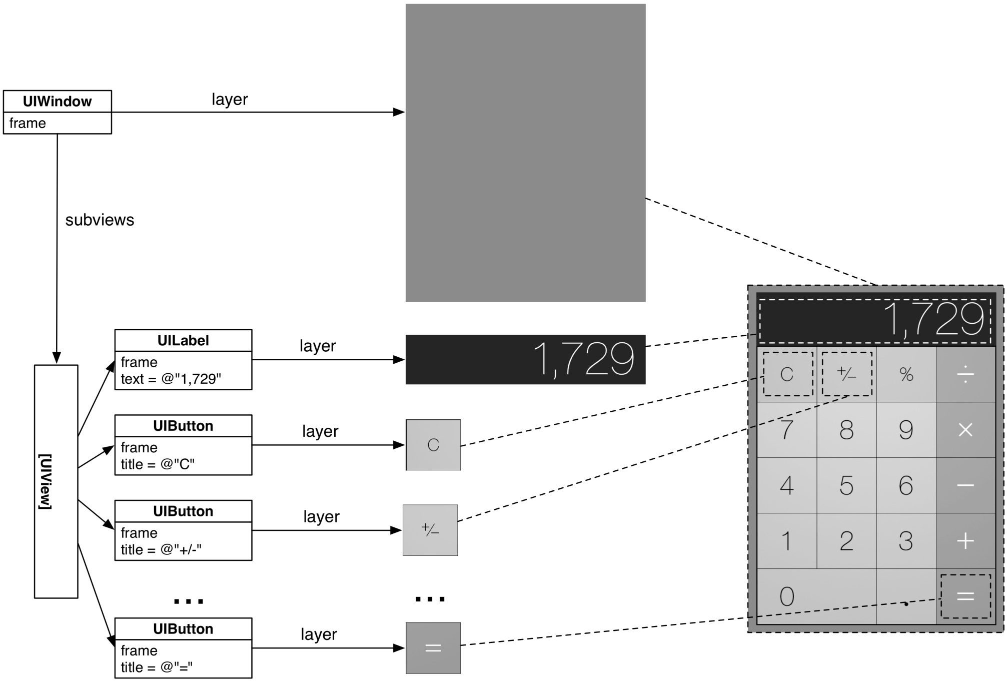
Once the view hierarchy is created, it will be drawn to the screen. This process can be broken into two steps:

- Each view in the hierarchy, including the window, draws itself. It renders itself to its *layer*, which you can think of as a bitmap image. (The layer is an instance of **`CALayer`**.)

- The layers of all the views are composited together on the screen.

Figure 3.3 shows another example view hierarchy and the two drawing steps.

Figure 3.3 Views render themselves and then are composited together



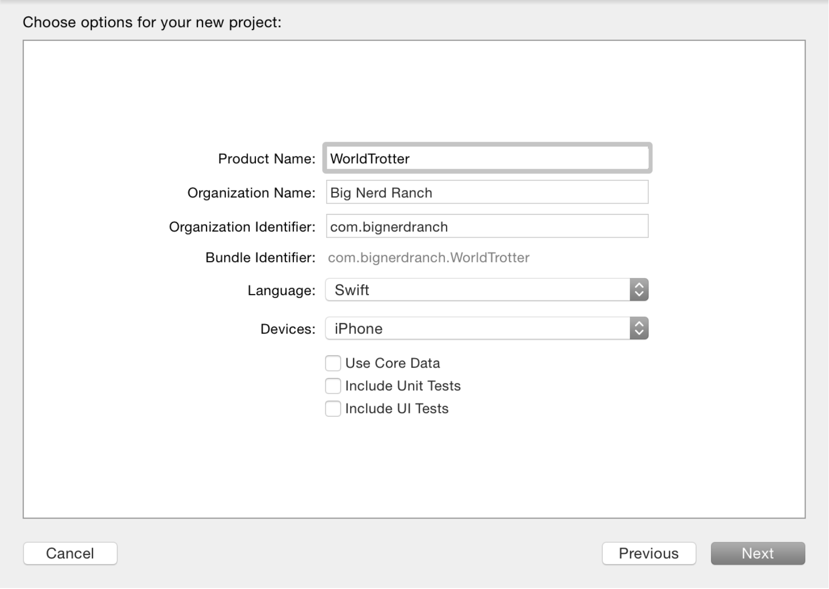
For WorldTrotter, you are going to create an interface composed of different views. There will be four instances of **`UILabel`** and one instance of **`UITextField`** that will allow the user to enter in a temperature in Fahrenheit. Let’s get started.

Creating a New Project

In Xcode, select File → New → Project... (or use the keyboard shortcut Command-Shift-N). From the iOS section, select Application, choose the Single View Application template, and click Next.

Enter WorldTrotter for the product name. Make sure that Swift is selected from the Language dropdown and that iPhone is selected from the Devices dropdown. Also make sure the Use Core Data box is unchecked (Figure 3.4). Click Next and then Create on the following screen.

Figure 3.4 Configuring WorldTrotter



Choose options for your new project:

Product Name: WorldTrotter

Organization Name: Big Nerd Ranch

Organization Identifier: com.bignerdranch

Bundle Identifier: com.bignerdranch.WorldTrotter

Language: Swift

Devices: iPhone

□ Use Core Data

□ Include Unit Tests

□ Include UI Tests

Views and Frames

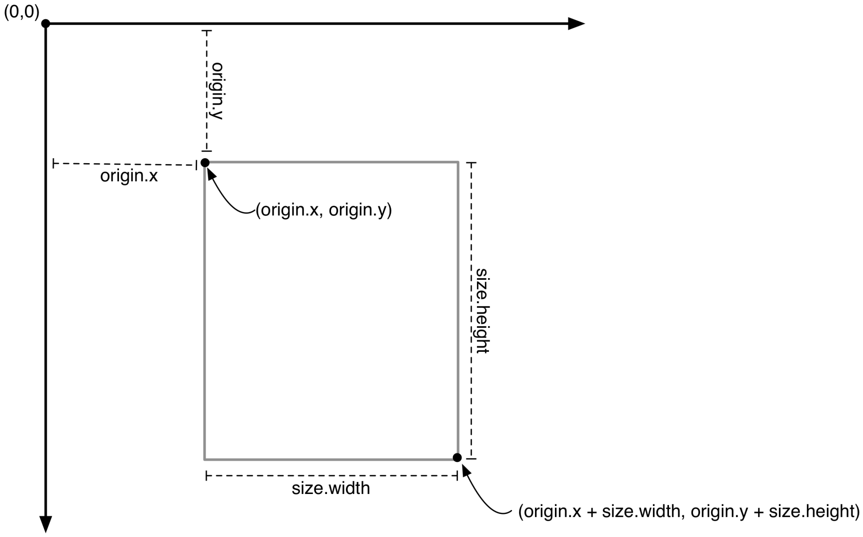
When you initialize a view programmatically, you use its **init(frame:)** designated initializer. This method takes one argument, a **CGRect**, that will become the view's frame, a property on **UIView**.

```
var frame: CGRect
```

A view's frame specifies the view's size and its position relative to its superview. Because a view's size is always specified by its frame, a view is always a rectangle.

A **CGRect** contains the members origin and size. The origin is a structure of type **CGPoint** and contains two **CGFloat** properties: x and y. The size is a structure of type **CGSize** and has two **CGFloat** properties: width and height (Figure 3.5).

Figure 3.5 CGRect



When the application is launched, the view for the initial view controller is added to the root-level window. This view controller is represented by the **ViewController** class defined in ViewController.swift. We will discuss what a view controller is in Chapter 5, but for now, it is sufficient to know that a view controller has a view and that the view associated with the main view controller for the application is added as a subview of the window.

Before you create the views for WorldTrotter, you are going to add some practice views programmatically to explore views and their properties and see how the interfaces for applications are created.

Open ViewController.swift and delete any methods that the template created. Your file should look like this:

```
import UIKit

class ViewController: UIViewController {

}
```

(Curious about the import UIKit line? UIKit is a *framework*. A framework is a collection of related classes and resources. The UIKit framework defines many of the user interface elements that your users see, as well as other iOS-specific classes. You will be using a few different frameworks as you go through this book.)

Right after the view controller's view is loaded into memory, its **viewDidLoad()** method is called. This method gives you an opportunity to customize the view hierarchy, so it is a great place to add your practice views.

In ViewController.swift, override **viewDidLoad()**. Create a **CGRect** that will be the frame of a **UIView**. Next, create an instance of **UIView** and set its backgroundColor property to blue. Finally, add the **UIView** as a subview of the view controller's view to make it part of the view hierarchy. (Much of this will not look familiar. That is fine. We will explain more after you enter the code.)

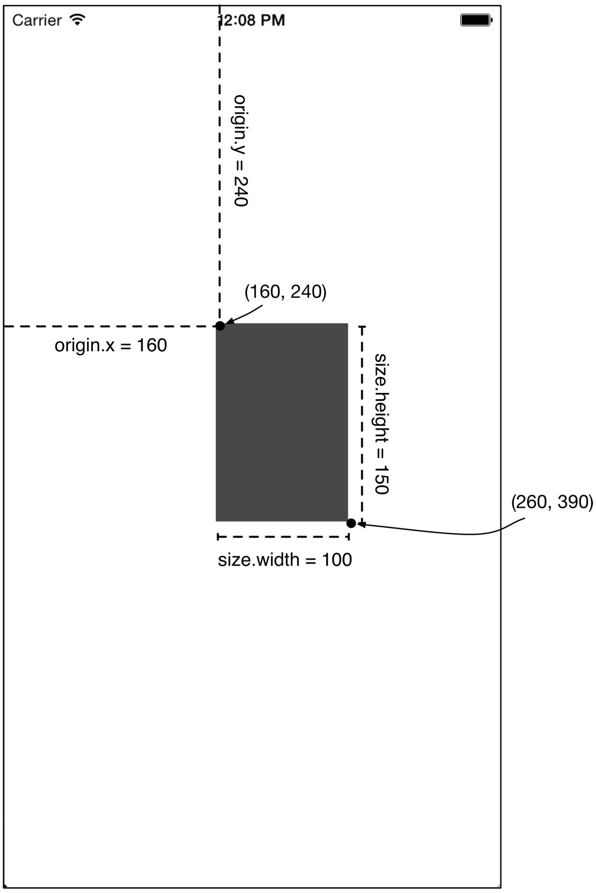
```
class ViewController: UIViewController {

    override func viewDidLoad() {
        super.viewDidLoad()

        let firstFrame = CGRect(x: 160, y: 240, width: 100, height: 150)
        let firstView = UIView(frame: firstFrame)
        firstView.backgroundColor = UIColor.blueColor()
        view.addSubview(firstView)
    }

}
```

To create a **CGRect**, you use its initializer and pass in the values for origin.x, origin.y, size.width, and size.height.

To set the backgroundColor, you use the **UIColor** class method **blueColor()**. This is a convenience method that initializes an instance of **UIColor** that is configured to be blue. There are a number of **UIColor** convenience methods for common colors, such as **greenColor()**, **blackColor()**, and **clearColor()**.

Build and run the application (Command-R). You will see a blue rectangle that is the instance of **`UIView`**. Because the `origin` of the **`UIView`**'s frame is `(160, 240)`, the rectangle's top left corner is 160 points to the right and 240 points down from the top left corner of its superview. The view stretches 100 points to the right and 150 points down from its `origin`, in accordance with its frame's `size` (Figure 3.6).

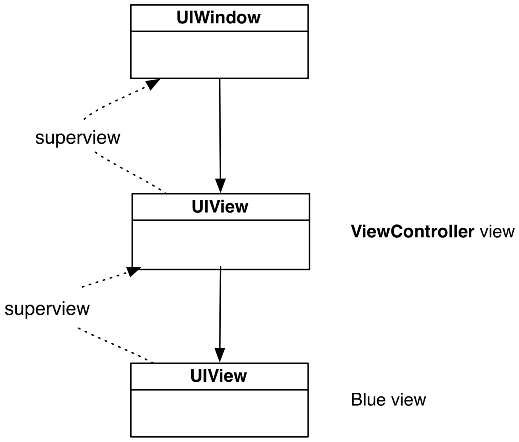
Figure 3.6 WorldTrotter with one **`UIView`**



Note that these values are in points, not pixels. If the values were in pixels, then they would not be consistent across displays of different resolutions (i.e., Retina vs. non-Retina). A single point is a relative unit of a measure; it will be a different number of pixels depending on how many pixels are in the display. Sizes, positions, lines, and curves are always described in points to allow for differences in display resolution.

Figure 3.7 represents the view hierarchy that you have created.

Figure 3.7 Current view hierarchy



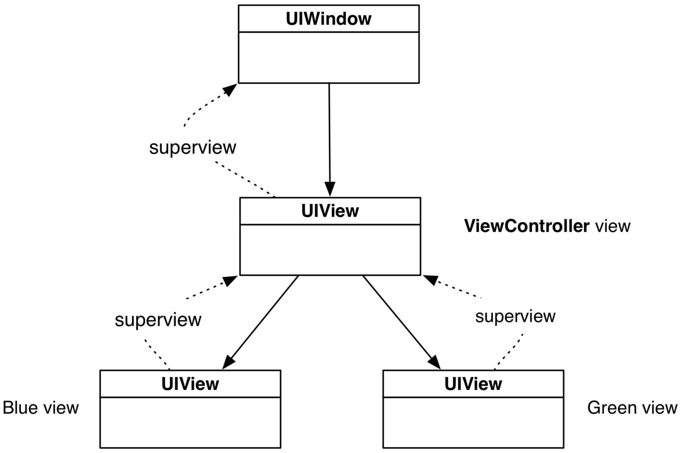
Every instance of **UIView** has a superview property. When you add a view as a subview of another view, the inverse relationship is automatically established. In this case, the **UIView**'s superview is the **UIWindow**.

Let's experiment with the view hierarchy. First, in ViewController.swift, create another instance of **UIView** with a different frame and background color.

```
override func viewDidLoad() {
    super.viewDidLoad()

    let firstFrame = CGRect(x: 160, y: 240, width: 100, height: 150)
    let firstView = UIView(frame: firstFrame)
    firstView.backgroundColor = UIColor.blueColor()
    view.addSubview(firstView)

    let secondFrame = CGRect(x: 20, y: 30, width: 50, height: 50)
    let secondView = UIView(frame: secondFrame)
    secondView.backgroundColor = UIColor.greenColor()
    view.addSubview(secondView)
}
```

Build and run again. In addition to the blue rectangle, you will see a green square near the top lefthand corner of the window. Figure 3.8 shows the updated view hierarchy.

Figure 3.8 Updated view hierarchy with two subviews as siblings

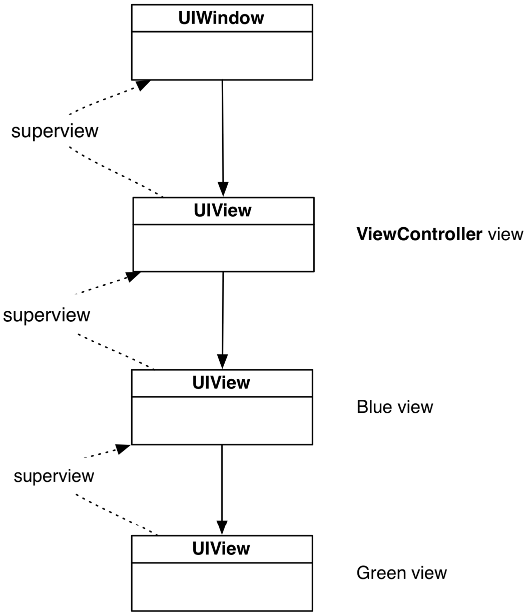


Now you are going to adjust the view hierarchy so that one instance of **UIView** is a subview of the other **UIView** instead of the view controller's view. In `ViewController.swift`, add `secondView` as a subview of `firstView`.

```
...

let secondView = UIView(frame: secondFrame)
secondView.backgroundColor = UIColor.greenColor()

~~view.addSubview(secondView)~~
firstView.addSubview(secondView)
```

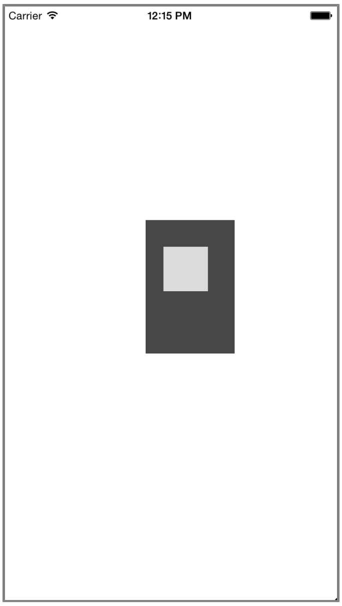
Your view hierarchy is now four levels deep, as shown in Figure 3.9.

Figure 3.9 One **`UIView`** as a subview of the other



Build and run the application. Notice that `secondView`'s position on the screen has changed (Figure 3.10). A view's `frame` is relative to its superview, so the top left corner of `secondView` is now inset `(20, 30)` points from the top left corner of `firstView`.

Figure 3.10 WorldTrotter with new hierarchy



(If the green instance of **UIView** looks smaller than it did previously, that is just an optical illusion. Its size has not changed.)

Now that you have seen the basics of views and the view hierarchy, you can start working on the interface for WorldTrotter. Instead of building up the interface programmatically, you will use Interface Builder to visually lay out the interface, as you did in Chapter 1.

In ViewController.swift, start by removing your practice code.

```
~~override func viewDidLoad() {~~
    ~~super.viewDidLoad()~~

    ~~let firstFrame = CGRect(x: 160, y: 240, width: 100, height: 150)~~
    ~~let firstView = UIView(frame: firstFrame)~~
    ~~firstView.backgroundColor = UIColor.blueColor()~~
    ~~view.addSubview(firstView)~~

    ~~let secondFrame = CGRect(x: 20, y: 30, width: 50, height: 50)~~
    ~~let secondView = UIView(frame: secondFrame)~~
    ~~secondView.backgroundColor = UIColor.greenColor()~~
    ~~firstView.addSubview(secondView)~~
~~}~~
```

Now let's add some views to the interface and set their frames.

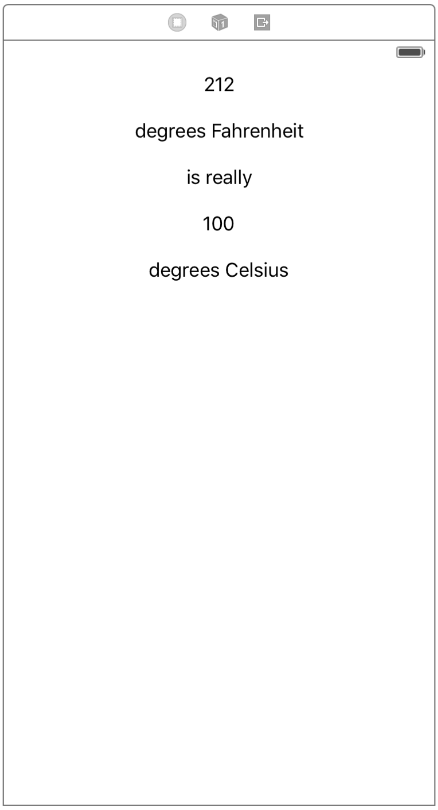
Open Main.storyboard. Notice that the interface on the screen is currently a square. While you explore views and their frames, it will be nice to have the size of the interface in Xcode match the screen size of the device that you will be using.

Select the View Controller either in the document outline or by clicking the yellow circle above the interface. Open the *attributes inspector*, which is the fourth tab in the utilities area. You can quickly open this pane using the keyboard shortcut Command-Option-4.

At the top of the pane, find the section labeled Simulated Metrics and change the Size to be iPhone 4.7-inch. This will resize the square interface to match the dimensions of the 4.7-inch devices.

From the object library, drag five instances of **`UILabel`** onto the canvas. Space them out vertically on the top half of the interface and center them horizontally. Set their text to match Figure 3.11.

Figure 3.11 Adding labels to the interface



212

degrees Fahrenheit

is really

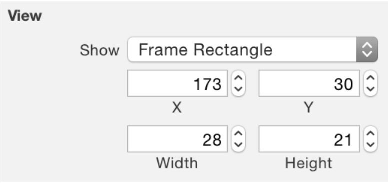
100

degrees Celsius

Select the top label so you can see its frame in Interface Builder. Open its *size inspector* – the fifth tab in the utilities area. (As you might have noticed by this point, the keyboard shortcuts for the utilities tabs are Command-Option plus the tab number. Since the size inspector is the fifth tab, its keyboard shortcut is Command-Option-5.)

Under the View section, find Frame Rectangle. (If you do not see it, you might need to select it from the Show pop-up menu.) These values are the view's `frame`, and they dictate the position of the view on screen (Figure 3.12).

Figure 3.12 View frame values



View

Show: Frame Rectangle

X: 173
Y: 30
Width: 28
Height: 21

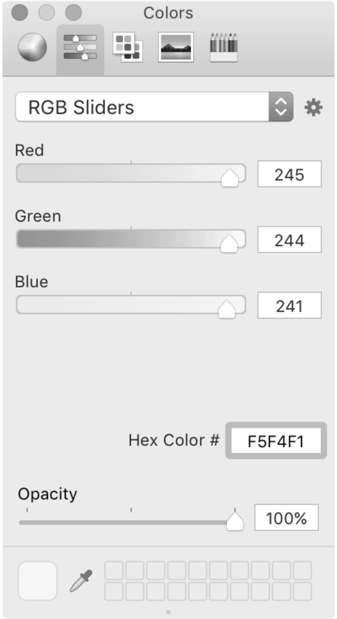
Build and run the application on the iPhone 6s simulator. This corresponds to the 4.7-inch simulated metrics that you specified in the storyboard. The interface on the simulator will look identical to the interface that you laid out in Interface Builder.

Customizing the labels

Let's make the interface look a little bit better by customizing the view properties.

In `Main.storyboard`, select the background view. Open the attributes inspector and give the app a new background color: Find and click the Background dropdown and click Other. Select the second tab (the Color Sliders tab) and enter a Hex Color # of F5F4F1 (Figure 3.13). This will give the background a warm, gray color.

Figure 3.13 Changing the background color



Red 245

Green 244

Blue 241

Hex Color # F5F4F1

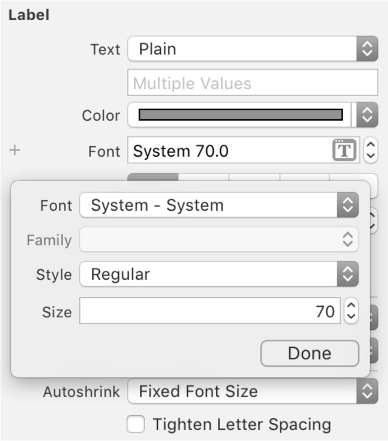
Opacity 100%

You can customize attributes common to selected views simultaneously. You will use this to give many of the labels a larger font size as well as a burnt orange text color.

Select the top two and bottom two labels by Command-clicking them in the document outline and open the attributes inspector. Update the text color: Under the Label section, find Color and open the pop-up menu. Select the Color Sliders tab again and enter a Hex Color # of E15829.

Now let's update the font. Select the 212 and 100 labels. Under the Label section in the attributes inspector, find Font and click on the text icon next to the current font. From the popover that appears, make the Font System - System and the Size 70 (Figure 3.14). Select the remaining three labels. Open their Font pop-up and make the Font System - System and the Size 36.

Figure 3.14 Customizing the labels' font



Label

Text: Plain

Multiple Values

Color

Font: System 70.0

Font: System - System

Family

Style: Regular

Size: 70

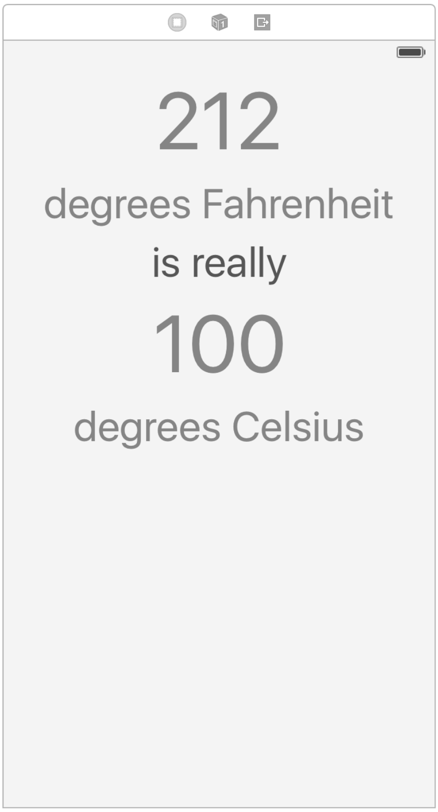
Autoshrink: Fixed Font Size

□ Tighten Letter Spacing

Now that the font size is larger, the text no longer fits within the bounds of the label. You could resize the labels manually, but there is an easier way.

Select the top label on the canvas. From Xcode's Editor menu, select Size to Fit Content (Command-=). This will resize the label to exactly fit its text contents. Repeat the process for the other four labels. (You can select all four labels to resize them all at once.) Now move the labels so that they are again nicely aligned vertically and centered horizontally (Figure 3.15).

Figure 3.15 Updating the label frames



212

degrees Fahrenheit

is really

100

degrees Celsius

Build and run the application on the iPhone 6s simulator. Now build and run the application on the iPhone 6s Plus simulator. Notice that the labels are no longer centered – instead, they appear shifted slightly to the left.

You have just seen two of the major problems with absolute frames. First, when the contents change (like when you changed the font size), the frames do not automatically update. Second, the view does not look equally good on different sizes of screens.

In general, you should not use absolute frames for your views. Instead, you should use Auto Layout to flexibly compute the frames for you based on constraints that you specify for each view. For example, what you really want for WorldTrotter is for the labels to remain the same distance from the top of the screen and to remain horizontally centered within their superview. They should also update if the font or text of the labels change. This is what you will accomplish in the next section.

The Auto Layout System

Before you can fix the labels to have them lay out flexibly, you need to learn a little theory about the Auto Layout system.

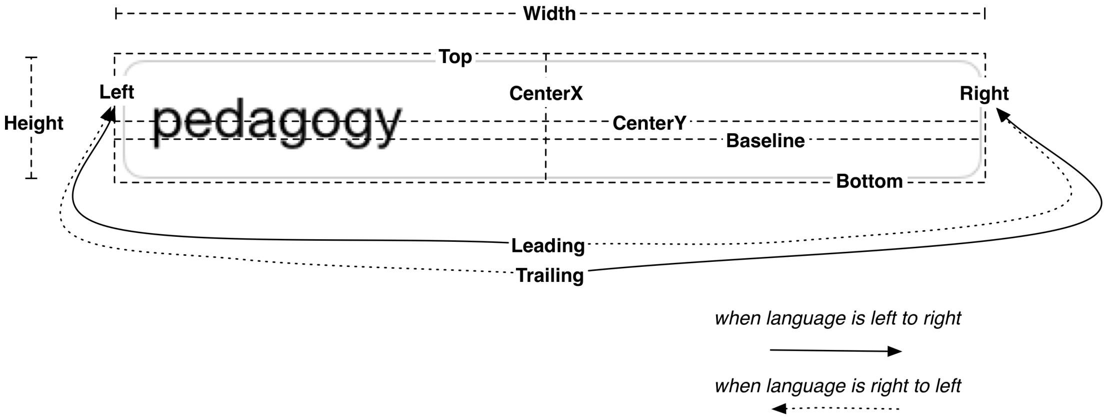
As you saw in Chapter 1, absolute coordinates make your layout fragile because they assume that you know the size of the screen ahead of time.

Using Auto Layout, you can describe the layout of your views in a relative way that enables their `frames` to be determined at runtime so that the `frames`' definitions can take into account the screen size of the device that the application is running on.

Alignment rectangle and layout attributes

The Auto Layout system is based on the *alignment rectangle*. This rectangle is defined by several *layout attributes* (Figure 3.16).

Figure 3.16 Layout attributes defining an alignment rectangle of a view



Width/Height

These values determine the alignment rectangle's size.

Top/Bottom/Left/Right

These values determine the spacing between the given edge of the alignment rectangle and the alignment rectangle of another view in the hierarchy.

CenterX/CenterY

These values determine the center point of the alignment rectangle.

Baseline

This value is the same as the bottom attribute for most, but not all, views. For example, **`UITextField`** defines its baseline as the bottom of the text it displays rather than the bottom of the alignment rectangle. This keeps "descenders" (letters like 'g' and 'p' that descend below the baseline) from being obscured by a view right below the text field.

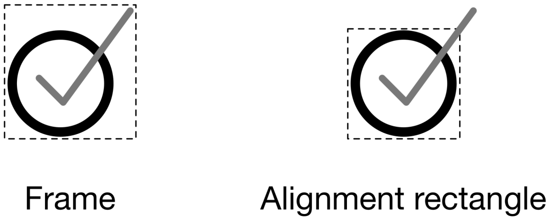
Leading/Trailing

These values are language-specific attributes. If the device is set to a language that reads left to right (e.g., English), then the leading attribute is the same as the left attribute and the trailing attribute is the same as the right attribute. If the language reads right to left (e.g., Arabic), then the leading attribute is on the right and the trailing attribute is on the left. Interface Builder automatically prefers leading and trailing over left and right, and, in general, you should as well.

By default, every view has an alignment rectangle, and every view hierarchy uses Auto Layout.

The alignment rectangle is very similar to the frame. In fact, these two rectangles are often the same. Whereas the frame encompasses the entire view, the alignment rectangle only encompasses the content that you wish to use for alignment purposes. Figure 3.17 shows an example where the frame and the alignment rectangle are different.

Figure 3.17 Frame vs. alignment rectangle



You cannot define a view's alignment rectangle directly. You do not have enough information (like screen size) to do that. Instead, you provide a set of *constraints*. Taken together, these constraints enable the system to determine the layout attributes, and thus the alignment rectangle, for each view in the view hierarchy.

Constraints

A *constraint* defines a specific relationship in a view hierarchy that can be used to determine a layout attribute for one or more views. For example, you might add a constraint like, "The vertical space between these two views should always be 8 points," or, "These views must always have the same width." A constraint can also be used to give a view a fixed size, like, "This view's height should always be 44 points."

You do not need a constraint for every layout attribute. Some values may come directly from a constraint; others will be computed by the values of related layout attributes. For example, if a view's constraints set its left edge and its width, then the right edge is already determined (left edge + width = right edge, always). As a general rule of thumb, you need at least two constraints per dimension (horizontal and vertical).

If, after all of the constraints have been considered, there is still an ambiguous or missing value for a layout attribute, then there will be errors and warnings from Auto Layout and your interface will not look as you expect on all devices. Debugging these problems is important, and you will get some practice later in this chapter.

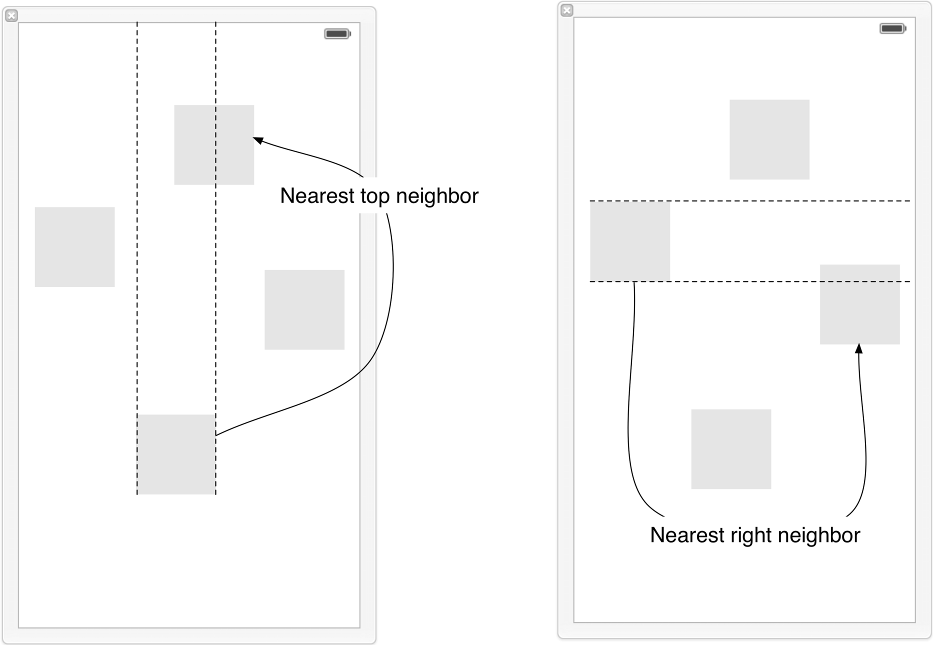
How do you come up with constraints? Let's see how using the labels that you have laid out on the canvas.

First, describe what you want the view to look like independent of screen size. For example, you might say that you want the top label to be:

- 8 points from the top of the screen
- centered horizontally in its superview
- as wide and as tall as its text

To turn this description into constraints in Interface Builder, it will help to understand how to find a view's *nearest neighbor*. The nearest neighbor is the closest sibling view in the specified direction (Figure 3.18).

Figure 3.18 Nearest neighbor



If a view does not have any siblings in the specified direction, then the nearest neighbor is its superview, also known as its container.

Now you can spell out the constraints for the label:

1. The label's top edge should be 8 points away from its nearest neighbor (which is its container – the `view` of the **`ViewController`**).
2. The label's center should be the same as its superview's center.
3. The label's width should be equal to the width of its text rendered at its font size.
4. The label's height should be equal to the height of its text rendered at its font size.

If you consider the first and fourth constraints, you can see that there is no need to explicitly constrain the label's bottom edge. It will be determined from the constraints on the label's top edge and the label's height. Similarly, the second and third constraints together determine the label's right and left edges.

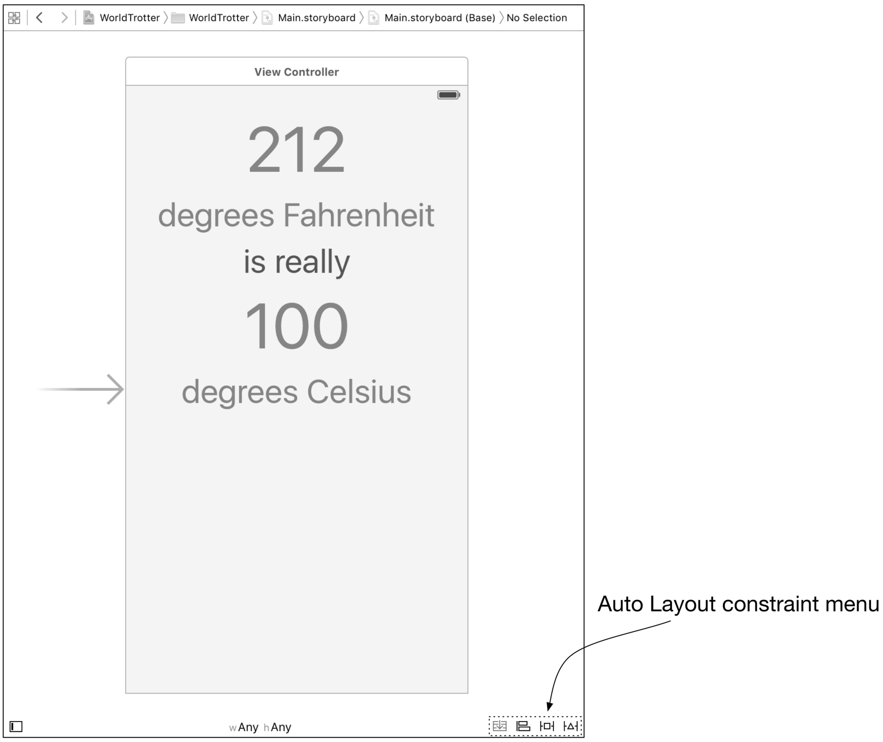
Now that you have a plan for the top label, you can add these constraints. Constraints can be added using Interface Builder or in code. Apple recommends that you add constraints using Interface Builder whenever possible, and that is what you will do here. However, if your views are created and configured programmatically, then you can add constraints in code. In Chapter 6, you will practice that approach.

Adding constraints in Interface Builder

Let's get started constraining that top label.

Select the top label on the canvas. In the bottom righthand corner of the canvas, find the Auto Layout constraint menu (Figure 3.19).

Figure 3.19 Using the Auto Layout constraint menu


WorldTrotter 〉 WorldTrotter 〉 Main.storyboard 〉 Main.storyboard (Base) 〉 No Selection
View Controller
212
degrees Fahrenheit
is really
100
degrees Celsius
wAny hAny

Auto Layout constraint menu

Click the ⊢◻⊣ icon (the third from the left) to reveal the Pin menu. This menu shows you the current size and position of the label.

At the top of the Pin menu are four values that describe the label's current spacing from its nearest neighbor on the canvas. For this label, you are only interested in the top value.

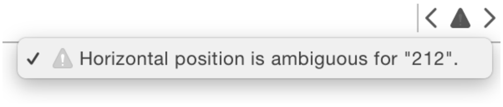
To turn this value into a constraint, click the top red strut separating the value from the square in the middle. The strut will become a solid red line.

In the middle of the menu, find the label's Width and Height. The values next to Width and Height indicate the current canvas values. To constrain the label's width and height to the current canvas values, check the boxes next to Width and Height. The button at the bottom of the menu reads Add 3 Constraints. Click this button.

At this point, you have not specified enough constraints to fully determine the alignment rectangle. Interface Builder will help you determine what the problem is.

In the top right corner of Interface Builder, notice the yellow warning sign (Figure 3.20). Click on this icon to reveal the issue: “Horizontal position is ambiguous for "212".”

Figure 3.20 Horizontal ambiguity



✓ ⚠ Horizontal position is ambiguous for "212".

You have added two vertical constraints (a top edge constraint and a height constraint), but you have only added one horizontal constraint (a width constraint). Having only one constraint makes the horizontal position of the label ambiguous. You will fix this issue by adding a center alignment constraint between the label and its superview.

With the top label still selected, click the ⊫ icon (the second from the left in the Auto Layout constraints menu) to reveal the Align menu. If you have multiple views selected, this menu will allow you to align attributes among the views. Since you have only selected one label, the only options you are given are to align the view within its container.

In the Align menu, select Horizontally in Container (do not click Add 1 Constraint yet). Once you add this constraint, there will be enough constraints to fully determine the alignment rectangle. To ensure that the frame of the label matches the constraints specified, open the Update Frames pop-up menu from the Align menu and select Items of New Constraints. This will reposition the label to match the constraints that have been added. Now click on Add 1 Constraint to add the centering constraint and reposition the label.

The label’s constraints are all blue now that the alignment rectangle for the label is fully specified. Additionally, the warning at the top right corner of Interface Builder is now gone.

Build and run the application on the iPhone 6s simulator and the iPhone 6s Plus simulator. The top label will remain centered in both simulators.

Intrinsic content size

Although the top label’s position is flexible, its size is not. This is because you have added explicit width and height constraints to the label. If the text or font were to change, you would be in the same position you were in earlier. The size of the frame is absolute, so the frame would not hug to the content.

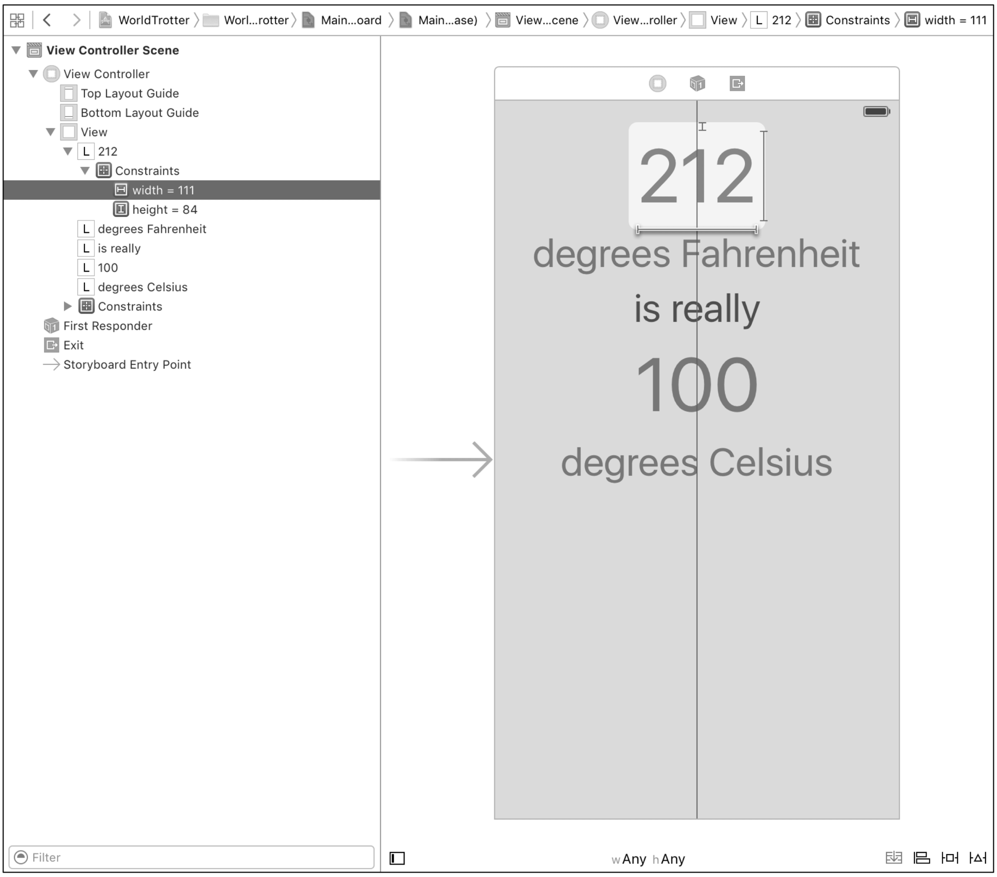
This is where the *intrinsic content size* of a view comes into play. You can think of the intrinsic content size as the size that a view “wants” to naturally be. For labels, this size is the size of the text rendered at the given font. For images, this is the size of the image itself.

A view’s intrinsic content size acts as implicit width and height constraints. If you do not specify constraints that explicitly determine the width, the view will be its intrinsic width. The same goes for the height.

With this knowledge, let the top label have a flexible size by removing the explicit width and height constraints.

In `Main.storyboard`, select the width constraint on the label. You can do this by clicking on the constraint on the canvas. Alternatively, in the document outline, you can click on the disclosure triangle next to the `212` label, then disclose the list of constraints for the label (Figure 3.21). Once you have selected the width constraint, press the Delete key. Do the same for the height constraint.

Figure 3.21 Selecting the width constraint



Notice that the constraints for the label are still blue. Since the width and height are being inferred from the label's intrinsic content size, there are still enough constraints to determine the label's alignment rectangle.

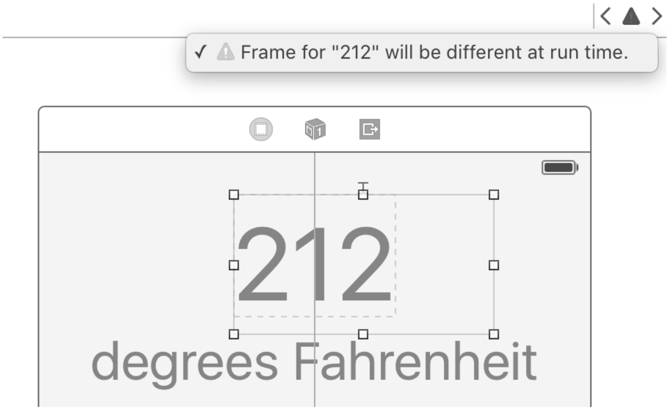
Misplaced views

As you have seen, blue constraints indicate that the alignment rectangle for a view is fully specified. Orange constraints often indicate a *misplaced view*. This means that the frame for the view in Interface Builder is different than the frame that Auto Layout has computed.

A misplaced view is very easy to fix. That is good, because it is also a very common issue that you will encounter when working with Auto Layout.

Give your top label a misplaced view so that you can see how to resolve this issue. Resize the top label on the canvas using the resize controls and look for the yellow warning in the top right corner of the canvas. Click on this warning icon to reveal the problem: “Frame for "212" will be different at run time” (Figure 3.22).

Figure 3.22 Misplaced view warning



✓ ⚠ Frame for "212" will be different at run time.

As the warning says, the frame at runtime will not be the same as the frame specified on the canvas. If you look closely, you will see an orange dotted line that indicates what the runtime frame will be.

Build and run the application. Notice that the label is still centered despite the new frame that you gave it in Interface Builder. This might seem great – you get the result that you want, after all. But the disconnect between what you have specified in Interface Builder and the constraints computed by Auto Layout will cause problems down the line as you continue to build your views. Let’s fix the misplaced view.

Back in the storyboard, select the top label on the canvas. Click the |△| icon (the right-most icon) to reveal the Resolve Auto Layout Issues menu. Select Update Frames from the Selected Views section. This will update the frame of the label to match the frame that the constraints will compute.

You will get very used to updating the frames of views as you work with Auto Layout. One word of caution: if you try to update the frames for a view that does not have enough constraints, you will almost certainly get unexpected results. If that happens, undo the change and inspect the constraints to see what is missing.

At this point, the top label is in good shape. It has enough constraints to determine its alignment rectangle, and the view is laying out the way you want.

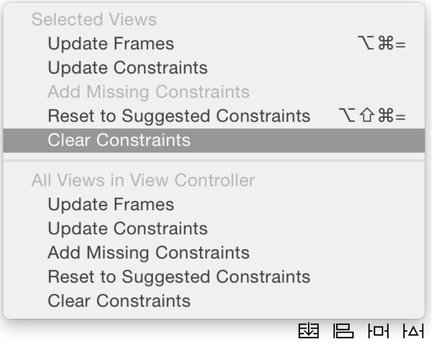
Becoming proficient with Auto Layout takes a lot of experience, so in the next section you are going to remove the constraints from the top label and then add constraints to all of the labels.

Adding more constraints

Let's flesh out the constraints for the rest of the views. Before you do that, you will first remove the existing constraints from the top label.

Select the top label on the canvas. Open the Resolve Auto Layout Issues menu and select Clear Constraints from the Selected Views section (Figure 3.23).

Figure 3.23 Clearing constraints



You are going to add the constraints to all of the views in two steps. First you will center the top label horizontally within the superview. Then you will add constraints that pin the top of each label to its nearest neighbor while aligning the centers of all of the labels.

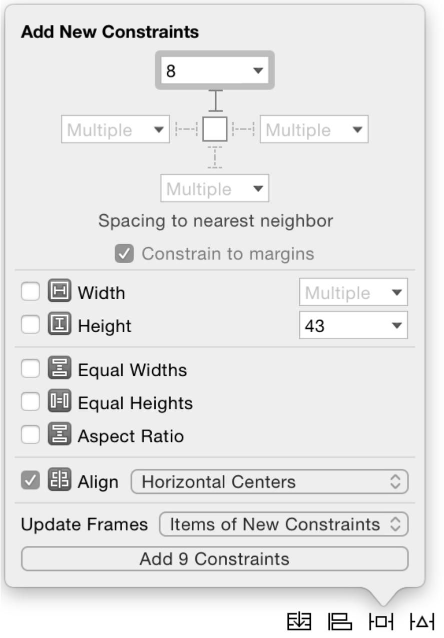
Select the top label. Open the Align menu and choose Horizontally in Container with a constant of 0. Make sure that Update Frames has None selected; remember that you do not want to update the frame of a view that does not have enough constraints, and this one constraint will certainly not provide enough information to compute the alignment rectangle. Go ahead and Add 1 Constraint.

Now select all five labels on the canvas. It can be very convenient to add constraints to multiple views simultaneously. Open the Pin menu and make the follow choices:

1. Select the top strut and make sure it has a constant of 8.
2. From the Align menu, choose Horizontal Centers.
3. From the Update Frames menu, choose Items of New Constraints.

Your menu should match Figure 3.24. Once it does, click Add 9 Constraints. This will add the constraints to the views and update their frames to reflect the Auto Layout changes.

Figure 3.24 Adding more constraints with the Pin menu



Add New Constraints

8

Multiple

Multiple

Multiple

Spacing to nearest neighbor

☑ Constrain to margins

□ Width Multiple

□ Height 43

□ Equal Widths

□ Equal Heights

□ Aspect Ratio

☑ Align Horizontal Centers

Update Frames Items of New Constraints

Build and run the application on the iPhone 6s simulator. The views will be centered within the interface. Now build and run the application on the iPhone 6s Plus simulator. Unlike earlier in the chapter, all of the labels remain centered on the larger interface.

Auto Layout is a crucial technology for every iOS developer. It helps you create flexible layouts that work across a range of devices and interface sizes. It also takes a lot of practice to master. You will get a lot of experience working with Auto Layout as you work through this book.

Now that the interface for WorldTrotter is using Auto Layout to adapt to various screen sizes, there is no need for you to specify an iPhone screen size when working in the storyboard.

In `Main.storyboard`, select the View Controller and open its attributes inspector. Find the Simulated Metrics section and change the Size to Inferred. The interface updates to be the square shape that it was initially. Notice that the labels still remain centered in this square interface due to the constraints that you added.

Designing interfaces using the inferred square shape helps to force you to think about designing adaptive interfaces that work with a variety of screen sizes instead of designing for one particular screen size.

Bronze Challenge: More Auto Layout Practice

Remove all of the constraints from the **`ViewController`** interface and then add them back in. Try to do this without consulting the book.

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